A STUDY OF ECCENTRICALLY LOADED REINFORCED CONCRETE COLUMNS

BY

RALPH NORMAN McMANUS

B.Sc., University of Alberta, 1942
M.Sc., University of Alberta, 1946

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ENGINEERING
IN THE GRADUATE COLLEGE OF THE
UNIVERSITY OF ILLINOIS, 1952

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1. Eivind Hognestad: "An Experimental Study of Combined Bending and Axial Load in Reinforced Concrete Members". A report of an investigation conducted by the Engineering Experiment Station, University of Illinois, 1950.

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Structural members subjected to combined bending and direct stress offer a particular problem in reinforced concrete since concrete is unable to withstand appreciable tension. Generally accepted design procedures on the North American continent recommend analysis based on elastic action for flexural members and analysis based on ultimate strength relationships for pure compression members in reinforced concrete. Eccentrically loaded columns may vary in action from pure flexure at the one extreme to pure compression at the other.

The purpose of this study is to develop simple design relationships for eccentrically loaded reinforced concrete columns which would fail in compression. Rectangular and circular columns are treated separately for the case of eccentric leading applied in a plane of symmetry of the member and parallel to its longitudinal axis.

The investigation is carried out by determining the dimensionless relationships between ultimate load, eccentricity and the factors affecting the strength of the column at three defined critical conditions. The critical conditions chosen are those corresponding to axial load at the one extreme, simultaneous compression-tension failure at the other extreme and an intermediate condition of zero stress in the reinforcement farthest from the eccentric load.

By observation of these relationships a single dimensionless expression is chosen to represent the variation of ultimate load with eccentricity for each of the two shapes of section investigated. The design relationship, in each case, is developed by applying a variable factor of safety (depending on the percentage of longitudinal reinforcement) to the general expression relating the ultimate load to the eccentricity.

A simplified expression for the critical eccentricity which would result in simultaneous compression-tension failure is presented for each of the two shapes of section investigated. These expressions are presented in graphical form to permit rapid determination of the range of application of the proposed design relationships.

A comparison between the design loads obtained by the thesis expressions and those obtained by applying the provisions of the American Concrete Institute Building Code is presented for a number of cases having different percentages and arrangements of reinforcement.[1]

This comparison indicates that the design loads obtained by applying the thesis expressions will be about 10 per cent smaller than those obtained by applying the provisions of this code. The maximum difference in the two techniques will occur when small eccentricities are considered. In general the thesis expressions do not have as wide a range of recommended application as is permitted in the code, but show a greater sensitivity to the arrangement of the reinforcement in rectangular columns.

The general conclusion is that the design curves and realtionships presented in the thesis may be used to obtain a rapid evaluation of the permissible design loads for rectangular and circular columns subjected to symmetrical bending and thrust. The proposed technique permits a line of demarcation to be drawn between tension and compression failures and is quite sensitive to the arrangement of the reinforcement in rectangular columns.

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1. A.C.I. 318 - 51, p. 644-645.

VITA

Ralph Norman McManus was born at Lomond, Alberta, on the 29th of December, 1918. He completed his high school education at Garneau High School, Edmonton, Alberta, in 1938, and entered the University of Alberta the same year. In May, 1942, he received the degree of B.Sc. in Civil Engineering and in the fall of that year returned to the University of Alberta as a member of the staff of the Department of Civil Engineering. He completed the requirements for the degree of M.Sc. in Civil Engineering in May, 1946, at the University of Alberta. In September, 1949, he was granted leave of absence from the University of Alberta to enrole in the Graduate College of the University of Illinois. He held Graduate Fellowships during the school years 1949-50 and 1950-51. His Professional experience has included supervision of construction and structural design for various firms on a consulting basis, carried out during the four and one-half months vacation each year while on the staff at the University of Alberta. He is a member of the Engineering Institute of Canada, the Association of Professional Engineers of Alberta, the American Concrete Institute and the Sectional Committee on Recommended Practice for Reinforced Concrete Design of the Canadian Standards Association.